Cole Crops

ATLANTIC PROVINCES VEGETABLE CROPS GUIDE TO PEST MANAGEMENT 2002 - 2003

Prince Edward Island
CANADA
Agriculture and Forestry
Farm Extension Services

Distributed By:
FARM EXTENSION SERVICES
P.E.I. DEPARTMENT OF AGRICULTURE AND FORESTRY

Publication No. 1400A
Agdex No. 250/600
Published January 2002

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Introduction

Cole crops are members of the cruciferae (mustard family).

Cole Crops include:

Cabbage - *Brassica olerace* var *Capitata*

Cauliflower - *Brassica oleracea* var *Botrytis*

Broccoli - *Brassica oleracea* var *Italica*

Brussels Sprouts - *Brassica oleracea* var *Gemmifera*

Kale - *Brassica oleracea* var *Acephala*

Kohlrabi - *Brassica oleracea* var *Gongylodes*

Cole crops originated from the word caulis (Latin) meaning stem or stalk of a plant. Today cole crops, means the stem brassicas.

It is assumed that the cabbage and kales originated in western Europe and that cauliflower and broccoli came from the Mediterranean region. Cabbages and kales were the first to be domesticated. Prior to cultivation and use as food, they were used mainly for medicinal purposes. The first description of cauliflower appeared in 1544. Brussels sprouts, named after the city in Belgium, did not occur until the beginning of the 19th century. The sprouting broccoli of today originated in the Mediterranean area. Cole crops are biennials but are generally grown as annuals. At the seedling stage, these different crops are hard to distinguish. Except for certain strains of cabbage, broccoli and tropical type cauliflower a cold period is necessary for flowering.

The brassica family are well adapted to cool season production. These plants are quite cold resistant. Young hardened cabbage plants can withstand -10 for a short time, older plants are less hardy. The growth rate of cabbage stops at 0°C and is quickest at 15°C to 20°C. Above 25°C growth stops. Cole crops require a regular water supply of 25 mm per week during the growing season. Shortage of water is detrimental for head development. The minimum temperature for seed germination is 5°C with an optimum germination temperature of 27°C, an optimum range of 7 to 27°C and a maximum germination temperature of 37°C. Cauliflower and broccoli will not stand temperatures as high or low as cabbage. High temperatures delay maturity and increase vegetative growth (number of leaves) and cool temperatures hasten maturity and may induce "bolting". Young hardened plants can withstand -5 to -10°C. An optimum growth rate occurs at 15°C to 22°C and growth stops above 30°C. Fluctuating temperatures may induce some cauliflower cultivars which are heading to revert back to the vegetative phase which results in poor quality curds (bract formation). Kale is the hardiest of all cole crops. It can withstand temperatures of -10 to -15°C. Kohlrabi is sensitive to cold temperatures. A week at 10°C will cause the plant to bolt.

Cole crops require soils that can provide continuous water throughout the season. Well drained, sandy loam soils are suited to early varieties, loamy and clay loam soils are suited to late ones. Late cultivars are somewhat tolerant of poor drainage. Well drained soils can be rotated closely since clubroot is easier to control.

Early cabbage is usually transplanted in late April or early May and maturity is usually in early July. With the use of plastics and earlier transplanting, cabbage can be matured in late June. Cabbage can then be in continuous supply until March of the following year. Some cabbage, especially for the cole slaw market, may be stored until June in the best refrigerated storage. Yields are low for early cabbage and highest for kraut and cole slaw cabbage. Marketable yields range from 20,000 to 40,000 kg per hectare.

With tunnel house production early cauliflower cultivars may produce in late June. Early field production does not start until early July. During the summer, cauliflower is generally available and with refrigerated storage is marketed until early December. Yields vary with the field and growing conditions from 800 to 2000 dozen per hectare.

Broccoli production and earliness depends on the degree of bolting but with the use of tunnel houses the first crop could be harvested in early June. Field production would begin in early July and continue until the end of October. With a short storage period the crop marketings are usually completed by late November. Due to head rot and bolting, yields are variable from 750 to 1500 dozen per hectare.

Brussels Sprouts are grown for fresh and processing markets and are harvested in late September, October and November. On the fresh market they may be sold early in September and the marketing period extended by refrigerated storage into December. Yields for both markets are 7000 to 9000 kg per hectare.

Kale and kohlrabi are grown only in small quantities for specialty markets.

The cole crops are extremely important to vegetable production in the Atlantic area. They are important fresh and processing crops which are increasing in consumption. They are well suited to the climate of this area. These crops do not require high amounts of labor and can be mechanized. There may also be wholesale speciality markets that could be developed for certain crops or cultivars in the cole crop family e.g. kohlrabi, red cabbage, savoy cabbage, mini cauliflower, fresh broccoli spears, broccoli crowns, cauliflower florets and mini cabbage. Kraut, eggrolls and coleslaws are processed in the Atlantic area as well as frozen cauliflower, broccoli and Brussels Sprouts.

Nutrient Content:

Broccoli: Very good source of Vitamins A and C; rich in potassium, calcium and phosphorus, folate; contains some iron. 250 mL (1 cup) cooked broccoli contains about 45 kilocalories.

Brussels Sprouts: Very good source of Vitamins A and C; rich in potassium and folate. Contains other nutrients in small amounts. 250 mL (1 cup) serving contains 58 kilocalories.

Cauliflower: Good source of Vitamin C, folate and potassium. Supplies small amounts of several minerals and vitamins to the diet. 250 mL (1 cup) cauliflower supplies 26 kilocalories.

Cabbage: Excellent source of Vitamin C. In addition to containing some B vitamins, cabbage supplies some potassium and calcium to the diet. 250 mL (1 cup) raw cabbage contains 21 kilocalories; cooked 58 kilocalories.

Research is now showing other health benefits from cole crops related to reducing the risk of cancer and heart disease.

Crop Establishment ▲ to Top

Seed Treatment - Cole crop seed can be sized and/or pelleted for precision seeding of module trays or direct seeding into the field. With the cost of hybrid

seed almost every seed must produce a marketable plant. Advances in quality seed both in terms of vigor and germination percentage has led not only to an increase in module transplant use but also a reconsideration of direct seeding. (See Guide to Pest Management disease sections for hot water and pesticide treatment).

Seeding/Planting - For early markets plants must be raised in greenhouses. About 5 to 6 weeks are required to produce transplants. Young plants with 4 or 5 leaves are generally superior to older ones. The temperature should be maintained between 13 and 24°C. Slight hardening is beneficial but severe hardening may stunt growth. Large or old plants of cauliflower and broccoli and those grown at low temperatures (10 to 15°C) are likely to button (bolt) if exposed to a period of cool weather after field setting. Plants may be grown in module trays, in peat blocks or in paper cells. Normally 300 to 350 grams of seed will produce enough plants for 1 hectare. Broccoli may have two plants per cell in some production systems where large terminal heads are not desired.

Plants for late crops may be planted in module trays, field seed beds, greenhouse seedbed, or direct seeded. (Space seedbed rows 25 to 30 cm apart and seed 20 seeds per 25 cm of row with a scatter shoe seeder.) When direct seeding, 550 to 850 grams per hectare are required since seed is generally planted at twice the final spacing. Direct seed two to three weeks earlier than transplanting for the same harvest date. Seed 0.6 to 1.2 cm deep. Most cole crops should not be direct seeded after mid to late June.

Planting Space	Distance Between Rows (cm)	Distance Between Plants (cm)
Cabbage, early	60-75	30-40
Cabbage, late	75-90	30-70
Cauliflower	60-90	35-50
Broccoli	60-90	30-40
Brussels Sprouts	75-90	30-45

The newer compact hybrids may be grown at closer spacings than the older traditional cultivars. With Brussels sprouts grown for a once over harvesting and especially where smaller sprouts are required for freezing, uniformity of the sprouts up the stem can be improved by growing the plants at a closer spacing, eg. 60 x 60 cm. For broccoli crops to be harvested during the hot humid weather of August, plant spacings should be increased to the wider end of the range recommended to help reduce head rot. For bed culture of broccoli, cauliflower and cabbage rows may be spaced closer together and plants spaced further apart. This spacing depends on the crop, the cultivar, the fertility program, the size of the crop desired for market and the desired maturity date.

Crop Management ▲ to Top

Cabbage splitting - It is mainly a problem with early cabbage. A problem can develop when moisture stress is followed by heavy rain. The rapid growth rate associated with rain, high temperatures and high fertility cause the splitting. Proper irrigation may help prevent splitting and there are significant differences between cultivars in their

susceptibility to this problem. Splitting may also be partially avoided by deep cultivation to break some of the plant roots.

Cauliflower and Broccoli buttoning - Buttoning is the premature formation of a head and because the head forms early in the plant's life, the leaves are not large enough to nourish the curd to a marketable size. Buttoning may occur shortly after planting in the field, when normal plants of the same age should be growing vegetatively. Losses are usually most severe in the early planted crop during cold, wet seasons, when vegetative growth is checked by: (1) too much hardening of greenhouse plants (2) too little hardening of greenhouse plants (3) low soil nitrogen (4) low soil moisture (5) continued cold weather (4 to 10°C for 10 days or more) (6) Other - disease, insects, micronutrient deficiency, etc. Some cultivars, particularly early ones, are more susceptible to buttoning than others.

Lack of heads in broccoli and cauliflower - During periods of extremely warm weather (days over 30°C and nights 25°C) broccoli and cauliflower can remain vegetative (does not head) since they do not receive enough cold for head formation. This can cause a problem in scheduling the marketing of even volumes of crop.

Tipburn of cauliflower and cabbage - This problem can cause severe economic losses. Tipburn is a breakdown of plant tissue inside the head of cabbage and on the inner wrapper leaves of cauliflower. It is a physiological disorder which is associated with an inadequate supply of calcium in the affected leaves causing a collapse of the tissue and death of the cells.

Calcium deficiency may occur where the soil calcium is low or where there is an imbalance of nutrients in the soil along with certain weather conditions. (High humidity, low soil moisture, high potash and high nitrogen aggravate calcium availability).

Secondary rot caused by bacteria can follow tipburn and heads of cauliflower can be severely affected. Some cultivars are relatively free of tipburn problems.

Hollow stem in broccoli and cauliflower - This condition starts with gaps that develop in the tissues. These gradually enlarge to create a hollow stem. Ordinarily, there is no discoloration of the surface of these openings at harvest but both discoloration and tissue breakdown may develop soon after harvest. Some cultivars of hybrid cauliflower may have openings from the stem into the head. Both plant spacing and the rate of nitrogen affect the incidence of hollow stem. As the plant spacing increases hollow stem increases. As the rate of nitrogen increases then the rate of hollow stem increases. The incidence of hollow stem can be greatly reduced by increasing the plant population.

Cauliflower blanching - The market demands cauliflower which is pure white or pale cream in color. Heads exposed to sunlight develop a yellow and/or red pigment. The usual method to exclude light is to tie the outer leaves when the curd is 8 cm in diameter. Leaves may also be broken over the curd to prevent yellowing. In hot weather blanching may take 3 to 4 days, but in cool weather, 8

to 12 days or more may be required. Some cultivars give better natural curd protection by having inner wrapper leaves, (without tieing) especially those cultivars which have been bred in Europe. Cauliflower fields scheduled to mature in cool weather (September and October) that are well supplied with water and planted with "self-blanching" cultivars will not need tieing.

Irrigation - The availability of water can be critical to successful production. Steady even growth of these crops are necessary for high quality and yields. Irrigation may also be used to cool plants during periods of high temperature. Fertilizer could also be applied through an irrigation system. Irrigation at the wrong time can cause problems such as head rot of broccoli and cauliflower.

Nutrition ▲ to Top

ALL ADDITIONS OF LIME AND FERTILIZER OR MANURES SHOULD BE BASED ON RECOMMENDATIONS FROM A SOIL TEST.

Cole crops are generally crops that require high amounts of fertility.

Manure - Half or more of the fertilizer can be replaced by 25 to 35 tonne per hectare. Do not use manure from animals that have been fed turnips or rutabagas. Excessive use of manure may contribute to tip burn, hollow stem, internal browning, head rot and other problems.

Lime - Lime should be applied to maintain the soil pH in the range 5.8 to 6.5.

Nitrogen - Adequate nitrogen produces a dark green color in cole crops leaves. Nitrogen deficient plant leaves are light green, eventually turn yellow and may be shed. There is a wide variation in the needs between cole crops and different cultivars of these crops. This is not generally recognized in soil test analysis sheets received from your soil lab. For early cabbage and broccoli the nitrogen can be totally broadcast preplant and incorporated into the soil. For cauliflower and late cabbage up to 3 sidedressings of nitrogen may be made. Foliar sprays of urea may also be applied.

Head rot of broccoli can be greatly aggravated by close spacing and high nitrogen during hot, humid weather conditions.

Phosphorus - A shortage of phosphorus stunts plants growth. Starter fertilizers high in phosphorus are recommended. Generally all the phosphorus is broadcast or all banded depending on the available transplanting equipment. Low rates of phosphorus are required at high phosphorus levels.

Potassium - Potash usually is applied but cole crops are not responsive to potash when compared to nitrogen. On soils high in potassium no additional potash may be needed. Excessive potash may lead to increased tip burn (internal and/or external). Potash competes with calcium for uptake from the soil and this is probably what causes the increased tip burn. When potash is applied it is usually broadcast and preplant incorporated into the soil.

Magnesium - Deficiency is fairly common especially on light acid soils where dolomitic limestone has not been applied. To correct this problem apply dolomitic limestone, add magnesium to the fertilizer and/or spray the foliage with epsom salts (magnesium sulfate).

Sulfur - On sandy soils low in organic matter that have been intensively cropped, soil sulfate levels may be low. Application of gypsum should be considered on these soils. Cole crops have the highest need of any crop for sulfur. Cauliflower, especially, have shown signs of deficiency in many fields.

Micronutrients *Boron* - Deficiency may cause hollow stem and/or stem discoloration and/or cracking as well as browning of cauliflower curds. On soils known to be deficient in boron apply a boronated fertilizer (.2 to .3B to give 1.0 to 2.5 kg per hectare of boron) and foliar sprays of soluble boron. On high pH soils (over 6) use only foliar sprays of boron. (Solubor at 3.3 kg per hectare).

Molybdenum - Deficiency causes whiptail in cauliflower, broccoli and Brussels sprouts. Molybdenum may be supplied as a seed treatment, as a foliar spray to transplants before field setting, in the transplant water or as a foliar spray. Apply 30 to 45 g of Sodium Molybdate per 100 L of transplant water or 280 g of Sodium molybdate as a spray in 1100 L of water per hectare. (Sodium molybdate is approximately 40% molybdenum). Excessive molybdenum is toxic to plants and animals - use with care. It will carry over in the soil.

Liming to a pH of over 6 is usually sufficient for cabbage but cauliflower and broccoli may show deficiency even when the soil pH is 7.

Manganese - Deficiencies may occur on sandy, over limed soils. Foliar sprays of manganese sulfate may be necessary to correct a deficiency.

Application Method - (1) Usually N, P & K are broadcast before planting and incorporated into the soil (2) N and P may be banded and the K harrowed into the soil before planting. (10 cm below and 10 cm to the side of the row (3) Where high rates of fertilizer are used half may be banded and half may be broadcast.

Sidedressings of nitrogen up to 112 kg of actual N may be applied through the growing season. Foliar sprays of urea may also be used (10 kg of urea per hectare).

Pests and Pest Control ▲ to Top

Weeds

Perennial weeds should be controlled prior to planting. Herbicides recommended for use on cole crops will not provide complete control of weeds, therefore it is important to grow cole crops on soil where the weed seed population is low. The weed seed reservoir in the soil can be reduced by crop rotation, summer fallow and stale seedbed technique. Care must be taken to avoid fields where residual

herbicides from previous years persist in the soil as crop injury may occur.

Diseases

Clubroot (fungus)

Characteristics: Clubroot is a soil borne disease which affects turnips and rutabagas, as well as cabbage, broccoli, Brussels sprouts, cauliflower and radish. The signs of disease vary from swellings on roots to severe malformation of the root, accompanied in many cases by wilting, and frequently death of the plant. Throughout the Atlantic Provinces, it is a major problem where poor management practices are followed.

The fungus (*Plasmodiophora brassicae Wor.*) causing this disease is usually present in areas where rutabagas and cole crops have been grown for many years. Once land becomes infested, it will remain so for at least 7 years. Any producer intending to grow cruciferous plants must appreciate this fact. Infected plants are stunted and usually take on a bluish tinge at first, later turning yellow. (Root maggot infested plants may also show the same signs). Wilting is most common on warm sunny days; plants may show little wilting early in the morning or late at night. Small to large spindle-like or slug-shaped swellings develop on the roots of cabbage and other cole crops, large out-growths and misshapen roots occur on turnip and rutabagas (root rot can occur with a severe infection).

The clubroot fungus enters the plant through the many fine hairs on the roots. The extent of the disease is affected by many factors. Moist, cool soils usually produce more diseased plants than dry, warm soil. The disease also thrives best in acid soils; that is, when the pH is below 7.2.

When clubbed plants rot and break down in the fall, the fungus spores are released into the soil, where they may live for many years, ready to infect any rutabaga or cole crop subsequently planted. Since the fungus spores are in the soil, movement of the soil by any means (boots, tools, wheels or wind and water, etc.) also spreads the disease.

Control: 1) One of the most important controls is to ISOLATE (if possible) or avoid use of infested fields for crucifer crops for about 7 years. The disease affects only the crucifer crops so any other crop may be planted as long as cruciferous weeds are not present.

2) Cattle fed infected plant material can pass the fungus spores in manure. Therefore, DO NOT APPLY CLUBROOT INFESTED MANURE on land to be used to grow crucifers. Put manure back on the field that contained the infected roots to prevent spreading disease to other fields or spread on permanent pasture land that will not be used for any susceptible crop and where run-off will not carry the disease to clean fields.

3) Practice a ROTATION. Do not grow a susceptible crop within a 5 to 7 year

period to avoid infestation.

4) ALL EQUIPMENT used on infested land must be washed down and preferably steam cleaned or disinfected to prevent carrying the disease to clean fields. Live steam delivered at 690 kPa pressure for 5 minutes is the best method to disinfect equipment. For disinfectants see the Atlantic Provinces Vegetable Crops Guide to Pest Management.

5) Every effort to CONTROL SUSCEPTIBLE WEEDS should be made. Weeds of the mustard family will maintain or increase the level of infestation of clubroot in a field. Examples of susceptible weeds that occur in the Atlantic area are as follows: wild radish, wild mustard, field penny cress (stinkweed), pepper grass, shepherd's purse, false flax, hare's ear mustard, worm seed mustard and yellow rocket.

6) As clubroot seems to thrive best in moist, acid soils it is advisable to APPLY LIME to raise the pH of the soil to at least pH 7.2. Wet, poorly drained land should be avoided or drainage improved. In Atlantic Canada this means a calcium level of 5000 to 6000 kg per hectare and a magnesium level of over 800 kg per hectare using the current testing method.

7) Use CLUBROOT-FREE TRANSPLANTS - The only way to ensure clean transplants is to use sterile soil. Clean boxes and equipment with steam. In the early stages of infection, plants may not show any signs of disease, so it is essential to purchase plants from a reliable source or to follow the procedures for producing healthy plants. Make sure you have enough clean plants for the area to be planted. Diseased plants beside healthy ones will result in all plants becoming infected. When growing transplants in the field, it is important to select a well drained area where it is known that clubroot has never occurred. Certain soil fumigants will control the clubroot organism.

Alternaria Leaf Spot (fungus)

Characteristics: Small to large black spots appear on leaves. It may be involved in discoloration and decay of cabbage heads, Brussels sprouts and cauliflower curds under very wet conditions. The disease organism is seed and soil borne. The first symptom of the disease is the appearance of small greyish-brown to black specks about 1 to 2 mm in diameter. These may appear at any time during the life of the crop. They usually are most conspicuous on the outer, older leaves. The spots enlarge in storage to sunken and black areas. *Alternaria* is a secondary fungus; it usually invades the plant after it has been injured by other pests or management practices.

Control: Use hot-water-treated seed. Practice long rotations between susceptible crops (turnips, cabbage, rape, other crucifers). Apply fungicides at first sign of disease at 7 to 10 day intervals. Cabbage intended for long-term storage should be treated 3 to 4 times ending 7 days prior to harvest. Keep storage temperature at 0°C and relative humidity at 92% to 95%. Periodic venting with outside cool air removes excess moisture from cabbage surface and reduces losses from

decay in common refrigerated storages.

Downy Mildew (fungus)

Characteristics: Shows as a white, fuzzy fungus in patches on underside of leaves, stems and heads. It may cause browning and black streaking in stems and black spotting on heads of broccoli and cauliflower.

Control: Rotate land for at least 2 years. Avoid thick seedings, over-watering and the application of water after 3 p.m. In the seedbed, spray seedlings at germination and repeat twice until transplanted with an appropriate fungicide. In the field apply fungicides on a regular basis as required.

Rhizoctonia (fungus)

Characteristics: The soil-borne fungus *Rhizoctonia solani* causes several diseases. Preemergence damping-off occurs when seeds are attacked and decay, or they may germinate but the young plants fail to emerge. Postemergence damping-off occurs when the stem of 2 to 5 cm tall plants are attacked. A water-soaked area completely encircles the stem near the soil line and the seedling wilts and topples over.

Wirestem results from an extension of the damping-off process but new infections may occur on plants 10-15 cm tall. The stem above and below the soil line darkens, and the outer cortex tissue decays and sloughs off in sharply defined area encircling the stem. The stem is thin and wiry at the lesion but remains erect. The plant may survive but will perform poorly. Some cauliflower cultivars are extremely susceptible to wirestem while others are more hardy.

Head rot of cabbage occurs during wet weather when the fungus attacks the bases of wrapper leaves causing them to drop off. The fungus may spread over the entire head and several layers deep. The head remains upright, dark and becomes studded with small, hard, brown fungal structures. The decay is initially firm, but soft-rotting bacteria may invade turning infected tissues soft and odorous.

Control: For damping-off and wirestem in seedbeds, only sterilized soil or soil that has not previously had crucifers for several years should be used. Seeds should be hot-water treated and also treated with a suitable fungicide. Plant density should permit adequate light and air penetration. Factors such as deep planting, reduced seed vigor and excessively cold, hot, moist or saline soils that delay seed emergence should be avoided. Deficiencies of calcium, potassium and nitrogen or excessive nitrogen may promote disease. A field rotation with noncruciferous crops should be practised for at least three years. Avoid mounding of soil onto lower leaves when cultivating.

Blackleg (fungus) and Black Rot (bacterium)

Characteristics: Early signs of blackleg appear as small spots on leaves of

young plants. On stems the spots are more linear and often surrounded by purplish borders. Stem lesions at the soil line usually extend to the root system causing dark cankers. The fibrous root system may be destroyed although new roots sent out above the lesion may keep the plant alive. Many plants wilt abruptly and die.

Black rot lesions first appear at margins of leaves. The tissue turns yellow and the lesion progresses toward the center of the leaf, usually in a V-shaped area with the base of the V toward the midrib. The veins become dark and discoloration frequently extends to the main stem and proceeds upward and downward.

Control: These organisms are seed borne and are capable of surviving in the soil for long periods without another cole crop (blackleg 3 years, black rot l year). Use only hot-water-treated seed and seed treated with antibiotic. Practice a 4-year rotation. Destroy cruciferous weeds as they may harbour the black rot organism.

Broccoli Head Rot (bacterium)

Characteristics: Head rot is caused by the soil borne bacterium *Pseudomonas marginalis*. Symptoms appear after periods of rain when heads remain wet for several days. The bacteria are splashed up from the soil to the head. When heads are colonized by the bacteria some areas appear water-soaked (because a biosurfactant is released by the bacteria) in contrast to unaffected areas where the waxy surface of the florets cause water to form in beads. Small black lesions may develop in these water-soaked florets. During long periods of wetness, decay spreads rapidly, resulting in a sunken area on the head. Head rot develops most rapidly at high temperatures (28°C).

Control: Avoid high levels of nitrogen and avoid applying pesticides during head formation as most pesticides contain surfactants which enhance rot during wet periods. For this reason, try to control insects prior to heading. The cultivars 'Shogun' and 'Arcadia' show good head rot resistance but only 'Arcadia' possesses good horticultural traits for the Maritimes. 'Green Valiant' and 'Patriot' possess moderate levels of resistance while 'Paragon', 'Emperor', 'Packman', 'Premium Crop' and 'Green Comet' are susceptible.

Insects

Cabbage Maggot

Characteristics: The adult is a two-winged, ash-grey fly with black stripes on the mid-section. It is half the size of a housefly, but has longer legs. Larvae are white, legless maggots. The pupae are 6 mm long, oval, hard shelled and dark brown. There are two to three generations a year. Pupae overwinter in the soil near the roots of the host plant. Adult flies emerge in the spring at about the time that Amelanchier and yellow rocket come into bloom. Adults fly close to the ground near host plants and lay elliptical white eggs on the stems or in nearby

crevices in the soil. Eggs hatch in three to seven days. Maggots enter the roots and feed by rasping the plant tissue with a pair of hook-like mouthparts. They mature in three to four weeks and pupate. Flies emerge in two to three weeks. Larvae (maggots) feed by tunnelling in the roots. Young plants may be stunted or killed. Feeding damage by the cabbage maggot causes roots to be misshapen and allows the entry of decay organisms and other species of maggots. The presence of adult flies can be determined by looking for eggs which are laid at the base of plants.

Control: Apply insecticides as listed in the Guide to Pest Management, or when eggs are first detected. A number of monitoring systems have been developed.

Cabbage Caterpillars: *Imported Cabbageworm, Cabbage Looper, Diamondback Moth Caterpillar, Purplebacked Cabbageworm*

Characteristics: Generally identified as green caterpillars, either large and velvety-green or small and active. These larvae eat holes in leaves and heads. Heavy infestations will virtually destroy the crop.

The adult of the Imported Cabbageworm is a white butterfly, easily seen going from plant to plant laying eggs during the summer. The eggs hatch into velvety-green larvae with one thin yellow stripe down the centre of its back. The cabbageworm larvae do not loop when they walk. They are generally the most prevalent of the caterpillars found on cole crops.

The cabbage looper gets its name from the way it forms a loop as it walks. It is a smooth green larvae with two white stripes along the back and two along the sides. The cabbage looper is capable of causing the most damage to cole crops. Cabbage loopers do not winter over in this region. Adult moths migrate into the region during the summer. Cabbage looper tends to be more problematic during late summer.

The Diamondback Moth is much smaller than the previous insects. Three to six generations of 1.1 cm yellow-green larvae may develop each year. The larvae squirm actively when disturbed and produce many small holes on the host plant. This pest can bore into the heads of Brussels sprouts and cabbage. Diamondback moths do not survive the winter in this region. Adult moths migrate in throughout the growing season. There is therefore often an overlap in generations, and all stages may be present at one time.

The Purplebacked Cabbageworm is not as commonly seen as the others but will cause serious damage in high numbers. The larvae are purple on the back and pale yellow along the sides. There are two generations per year.

Control: Check plants frequently and treat when damage is first observed and repeat at 7 to 10 day intervals. Include a spreader-sticker with all insecticide sprays and use enough water to wet the plants thoroughly. There are parasites that can also help keep a population in check.

Aphids

Characteristics: Aphids are small, soft-bodied, slow-moving insects. They are often found in large colonies on the undersurface of leaves. A colony consists of winged and wingless adults and various sizes of nymphs. Aphids may be black, yellow or pink, but mostly are various shades of green. Aphids feed by sucking plant sap. Feeding by large numbers may slow plant growth. The plants may be covered by a sticky substance, called honey dew, which is excreted by the aphids.

Control: Apply recommended pesticides when aphids are numerous.

Onion Thrips

Characteristics: The onion thrip is sometimes a pest on cabbage. They are slender, yellow-brown insects about 1 mm long. They feed by puncturing the leaves and sucking up the exuding sap. This causes the appearance of dark warts or blisters on the leaves. Once thrips enter the protection of the head, they will breed profusely. The injury may occur up to 20 layers deep in the head. They overwinter on refuse, weeds, and legume forage crops. Populations increase quickly when the air temperature is over 21°C.

Control: Destroy refuse and control weeds. Heavy migrations of thrips can occur following the cutting of forage, particularly alfalfa or clover. It is critical to control them at early head formation (7.5 cm leaf ball). Some cultivars of cabbage are highly resistant to this pest.

Fleabeetles

Characteristics: Fleabeetles are small shiny black beetles, about 2 mm in length. They chew small pinholes through the leaves of cole crops. They are very active early in the growing season, especially during periods of dry sunny weather. Fleabeetles can seriously damage seedlings and transplants. Fleabeetle damage is usually less serious to larger plants. There is one generation per year. The larvae live in the soil and feed on roots.

Control: Young plants can be protected by spraying with one of the insecticides listed in the Guide to Pest Management.

Cutworms

Characteristics: Cutworms are greyish, fleshy caterpillars up to 5 cm long, which curl up when disturbed. Plants may be chewed off above or below ground level and may be damaged higher up by climbing cutworms. Most of the cutworm damage is to newly set plants in the field, but they are often found attacking seedlings in plant beds and greenhouses. Late infestation of variegated cutworm occasionally occurs.

Control: Apply insecticides when early cutworm injury is detected.

Tarnished Plant Bug

Characteristics: Adult tarnished plant bugs are light brown to reddish brown in colour and about 5-6 mm in length. They occur throughout the season. They are very active and quick moving. They can damage cauliflower by feeding on the curd. They cause brown blemishes which reduces the marketability of the head.

Control: Keep plantings and adjacent areas weed free. Avoid planting adjacent to legumes. Insecticide controls for worms may also control this pest.

Slugs

Characteristics: Slugs exist in various sizes up to 10 cm. They eat holes in the leaves and leave a trail of mucus, which makes plants unsightly. The control of slug populations has been a continuing problem in the cole crop industry. They are especially troublesome in Brussels sprouts.

Control: Slugs prefer areas which are cool, moist and high in organic matter. Sod crops, weedy fence lines and hedgerows fulfil these conditions. Since slugs can overwinter fairly easily, cultural practices aimed at controlling them should begin at least one year before the susceptible crop is put in. If possible, sod crops should not be followed by cole crops. A cultivated strip around the crop has been shown to reduce the number of slugs migrating from weedy field borders. If urea (4 kg/ha) is sprayed on this cultivated strip, slug movement may be further impeded. The salt irritates the slugs as they move over it. Repeated applications are necessary as rainfall washes it into the soil.

Slugs are usually more numerous in heavy, moist soils; sandy soils usually have fewer slug problems.

Non-parasitic Disorders

Cole crops show various non-parasitic disorders which cause tissues to die off. In some cases, these deviations have been shown to depend mainly on heritable characters; whereas in other cases external factors had at least marked effect.

Internal Browning

Characteristics: In Brussels sprouts, the symptoms are a yellowing of the distal ends of the leaves within the sprout, generally on a line through the center region of the sprout and midway between its growing point and exterior surface. From a practical aspect, "internal browning" is especially troublesome because it cannot usually be detected from external examination of the sprouts, yet quite a small number of affected sprouts may taint a large sample - especially when they are blanched for quick-freezing.

Factors which have contributed to internal browning have done so by bringing about a temporary localized calcium deficiency in the sprouts. Rapid growth, low soil moisture and high relative humidity, which inhibits transpiration are

commonly implicated. The actual soil calcium levels have very little influence unless they are extremely low.

Control: Ensuring the soil moisture is close to field capacity can reduce the risk of internal browning. Excessive nitrogen fertilizer should be avoided. Foliar sprays of calcium nitrate may prevent the onset of internal browning if applied before the onset of adverse growing conditions.

SPECIFIC CHEMICAL CONTROLS FOR THE VARIOUS CROP PESTS DISCUSSED MAY BE FOUND IN THE ATLANTIC PROVINCES VEGETABLE CROPS "GUIDE TO PEST MANAGEMENT".

Harvesting and Handling ▲ to Top

Cabbage

Heads of cabbage can withstand some frost, although fairly large differences in frost hardiness occur between the varieties. Frozen tissues generally have a water soaked appearance, but if not damaged the tissues will look normal again after thawing. On the other hand, damaged tissues often show brown discolorations. The youngest leaves are particularly sensitive to frost, so that the center of the head may be damaged by frost and turn brown, while outwardly the head looks healthy. These disorders also occur in the buttons of Brussels sprouts.

Brussels sprouts

a) Topping: Topping checks stalk elongation and promotes the development of the individual sprouts.

The most advantageous time for topping (that which will produce uniform sprouts on the entire length of the stalk) has not been firmly established. Indications are for 'Jade Cross' that topping is best with initiation of sprouts on the seventh whorl on the stalk. This usually occurs in early September.

b) De-leafing: This practice has no benefit for sprout development. However to facilitate harvest, de-leafing may be necessary immediately prior to harvest.

c) Stem-cutting: Harvesting commences when the sprouts have reached marketable size and firmness. This can also be accomplished by hand or by a machine in combination with a conveyor system that loads the stalks directly onto a truck.

d) Transport to Stripping Point: The latter may be a hand-trimming bench in a packhouse; or a machine stripper in a packhouse, on the field headland, or on a trailer moving up and down the field.

An increasingly popular method of harvesting, especially with larger growers, is the use of the so-called 'sprout combines'. Sprouts should be solid and their outer leaves should be tightly clasping and not yellow in color. Sprouts with small,

loose leaves at the base are considered to be of medium quality, while those with many loose leaves and an open top are of poor quality. The sprouts should preferably be dark green, as they retain their attractive appearance longer than do light green ones.

Cauliflower

Before the curd becomes visible, it should be covered to prevent it from turning yellow. Generally, this is done by tying the large wrapper leaves together at the top.

Cauliflowers are harvested before the curds grow loose, generally some days after they have become visible. The length of the harvesting period depends on the weather.

The size of the curds varies widely with the growing conditions, the largest curds attaining a diameter of 30 cm or more. Early cauliflower is generally smaller than late cauliflower. Frequently preference is given to medium sized curds between 15 and 25 cm in diameter, while those under 10 cm are unacceptable.

More important than the size of the curd is its quality. A good curd must be regular in shape, globular, firm and white in color. Bracts and riceyness cause an inferior product.

Curds are sometimes marketed without foliage, but it is better to harvest them with a whorl of leaves still attached for protection. When the cauliflowers are to be transported in flat crates, the upper part of the foliage is generally removed. As a rule, the heads are packed in a single layer to reduce the risk of damage. When the heads are to be transported loose or in high crates, as little foliage as possible should be cut away.

Broccoli

It is vitally important that broccoli should be harvested at the correct time: the heads must be picked before the buds open and when the bud-clusters are still compact. Yellow buds and loose clusters spoil the product.

The terminal heads mature first. By removing the main head the growth of the lateral heads is promoted. As the lateral heads develop unevenly, they cannot all be harvested at one time; indeed, in warm weather harvesting is done at least twice a week.

The heads are usually harvested with about 15 cm of the stem attached. After they have been cut off, part of the foliage is removed from the harvested shoots. The heads are from 5 to 25 cm in diameter and weigh from 100 to 800 g each. Side-shoots are from 5 to 10 cm in diameter and weigh from 100 to 500 g each. Broccoli intended for fresh consumption is often sold in bunches weighing about 450 to 600 g. As the quality of harvested heads soon declines, they should be

marketed immediately. Rapid precooling and refrigeration is important.

Storage and Conditioning ▲ to Top

Cabbage is most satisfactorily stored at about 0°C and 98% to 100% relative humidity. In these conditions, cabbages may be stored for as long as eight months. Cabbages that are destined for storage are trimmed of their outer leaves, while careful handling is of importance to prevent injuring the wrapper leaves. Controlled atmospheres of 2.5% to 5% oxygen and 2.5% to 5% carbon dioxide may extend the storage life by several months. Avoid storing cabbage with any product that emits ethylene such as apples or pears as this can cause premature yellowing and abscision of leaves.

Cauliflower keep for 2 to 6 weeks at 0°C and relative humidity above 95%. Heads should be cooled to 5°C or below soon after harvest. Both hydrocooling and vacuum cooling are effective methods to remove field heat. Cauliflower that is destined for storage is preferably cut slightly immature; otherwise the curds may separate. Perforated plastic film overwraps are effective in reducing water loss during storage and marketing. Controlled atmospheres do not extend the storage life of cauliflower and may cause off-odours, softening or discoloration.

Brussels sprouts at 0°C and above 95% relative humidity will keep for 3 to 5 weeks. At -2°C, sprouts can be stored for a longer period, but have to be thawed slowly later on. Sprouts can be cooled following harvest using hydrocooling, vacuum cooling or icing. Similar to cabbage , exposure to ethylene will accelerate yellowing and cause leaf abscission. Controlled atmospheres of 2.5% to 5% oxygen and 5% to 7.5% carbon dioxide will increase the storage life of sprouts held at 5 or 10°C, but have no benefit at 0°C.

Broccoli is highly perishable and should be cooled immediately following harvest by hydrocooling or packing in ice. If held at 0°C and near 100% relative humidity, broccoli can be held for 3 to 4 weeks. Exposure to ethylene will accelerate the yellowing of flower buds and reduce storage life and should be avoided. Controlled atmospheres of 10% carbon dioxide with or without reduced oxygen can slow yellowing of heads at temperatures above 0°C. Hot water dips of broccoli ranging from 47°C for 10 minutes to 50°C for 2 minutes prior to cooling prevents yellowing and reduces decay of flower heads.

Bibliography ▲ to Top

(See also General References)

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RV96

Prepared by: Horticulture Section, Production Technology Branch, Nova Scotia Department of Agriculture & Marketing on behalf of APASCC and members:

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Weeds

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PEST	PESTICIDE (Formulation)	RATE Product	DAYS TO HARVEST	REMARKS
Preplant Perennial Weeds including quackgrass	ROUNDUP 356 Sn	2.5 to 7.0 L/ha	-	Apply in the fall or spring prior to planting. Annual weed control programs will be necessary to control weeds germinating after planting. For quackgrass control apply to actively growing quackgrass when at least 4 new leaves are present. The low rate (2.5 L/ha) will provide a minimum of one season control, while higher rates (4.75 to 7 L/ha) will provide longer term control. The low rate of Roundup should be applied in 50 to 100 L/ha water. If higher water volumes are used add a suitable surfactant. Wait 72 hours before plowing under. Best control of quackgrass is obtained when these herbicides are applied in the fall.
	TOUCHDOWN 480	2.5 to 7.0 L/ha	-	
	GLYFOS	2.5 to 7.0 L/ha	-	
	ROUNDUP TRANSORB	2.5 to 7.0 L/ha	-	
Preplant Incorporated Germinating annual grasses and some broadleaf weeds	TREFLAN 480 EC	1.2 to 2.3 L/ha	-	Preplant incorporated in direct seeded cabbage and cauliflower or transplants of cabbage, cauliflower, broccoli, and brussels sprouts. Incorporate within 8 hours of application following label instructions. Ragweed and mustards are not controlled. Corn or cereal grains may be injured when planted in fields treated with trifluralin the previous year.
	RIVAL 60 DF	1.0 to 1.9 kg/ha	-	
	BONANZA 400	1.5 to 2.75 L/ha	-	
Preemergence Treatments Germinating	DACTHAL 75 WP (no longer	9.0 to 15.5 kg/ha	-	Apply immediately after seeding or directly over transplants but before weeds emerge. Rainfall or irrigation is necessary for activity. Ragweed, nutsedge, smartweed and mustards are not controlled.

grasses and some broadleaf weeds	being manufactured)			
	DEVRINOL 50 DF	2.24 to 4.5 kg/ha	60	Apply to transplanted cabbage, cauliflower and broccoli only.
Stale Seedbed Technique	GRAMOXONE 200 Sn	2.75 to 5.5 L/ha	-	Apply in 300 to 1100 L of water/ha to foliage of the emerged weeds but before the crop has emerged. Use Gramoxone for best control of grasses.
	REGLONE 200 Sn	2.75 to 5.5 L/ha	-	
Broadleaf control	LONTREL 360	0.56 L/ha	30	Apply post transplant to cabbage, cauliflower and broccoli. Apply in 300 L of water/ha. Adequate testing on different varieties has not been completed in Atlantic Canada.
Postemergence Emerged Annual Grasses	EXCEL SUPER	0.67 L/ha	60	Apply to actively growing annual grasses in the 1 to 6 leaf stage. For use on cabbage, broccoli and cauliflower.
	POAST 184 EC plus MERGE or ASSIST	0.8 to 2.7 L/ha 1 L/ha 2 L/ha	70	Use on cabbage, cauliflower and broccoli. Treat at the 1 to 6 leaf stage of annual grasses. Use the higher rate for control of volunteer cereals. Apply in 110 to 200 L/ha water. Do not exceed 1.12 L/ha on broccoli.
	FUSILADE II 125 EC	0.8 to 1.0 L/ha	40	Apply to annual grasses at the full 2 to 5 leaf stages (2 to 4 leaves for foxtails). One application per season.
Postemergence Emerged Quackgrass	POAST 184 EC plus MERGE or ASSIST	2.7 L/ha 2 L/ha	70	Use on cabbage and cauliflower only. Thorough preplant tillage will ensure more uniform quackgrass emergence. Apply at 1 to 3 leaf stage of actively growing quackgrass in 110 to 200 L/ha water. Use merge at 1.0% volume/volume water.
	FUSILADE II 125 EC	2.0 L/ha	40	Apply to actively growing plants with 3 to 5 fully developed leaves. Rhizomes should be thoroughly fragmented by tillage prior to application. Inter-row cultivation should not occur until 5 days after application.
Postemergence Seedling annual broadleaf weeds lamb's quarters and redroot pigweed	LENTAGRAN 45 WP	2.0 kg/ha	45	May be applied following a ppi application of trifluralin. Use on direct seeded or transplanted cabbage only. Apply on direct seeded cabbage when fully developed true leaves form but prior to head formation. For transplanted cabbage, wait until well established (approx. 14 days after transplanting) but before head formation. Cabbage leaves coming in contact with Lentagran may become discolored.
Inter-row shielded	GRAMOXONE 200 Sn	2.75 to 5.5 L/ha	-	Do not spray solution on the crop plant since it could be injured or killed. Use Gramoxone for best control of grasses.
	REGLONE 200 Sn	2.75 to 5.5 L/ha	-	
Insects				

PEST	PESTICIDE (Formulation)	RATE Product	DAYS TO HARVEST	REMARKS
Root maggots Transplant Water Treatment	GUTHION 50 WP	100 g/ 100 L	21	Apply 100 to 150 ml per plant of the solution. Keep mixture well stirred.
	SNIPER 50 WP	100 g/ 100 L	-	
	AZINPHOS- METHYL 50 WP	100 g/ 100 L	21	
	APM 50 WP	100 g/ 100 L	21	
	LORSBAN 50 WP	65 g/ 200 L	32	For cabbage only. Do not use starter fertilizer or lindane with Lorsban 50 W.
Root maggots Transplant Granular Treatment	LORSBAN 15 G	0.6 to 1 kg per 1000 m row	40	Apply in furrow at planting time.
Root maggots Transplant Drench Sprays	GUTHION 50 WP	100 g/100 L	-	Keep mixture well stirred. Apply the mixture using a suitable drenching nozzle. Treatment should be applied within 2 days of transplanting. After the transplants straighten up, cover the insecticide lightly with soil to minimize harm to beneficial predators and parasites.
	SNIPER 50 WP	100 g/100 L	-	
	APM 50 WP	100 g/ 100 L	-	
	LORSBAN 4E	3.5 L/ha in 1000 L/ha	32	Apply 3 days after transplanting, row width 60 cm.
Root maggots Field Seedling	LORSBAN 4 E	1.68 L/ha in 1000 L/ha	32	Apply 12.5 L per 100 m of row, 10 cm on each side of the plant. Apply 7 to 10 days after seeding, 60 cm row width.
Cabbage looper cabbageworm Diamondback moth larvae		Action Threshold		Cole crops should be checked on a regular basis for the presence of caterpillars, beginning just after transplanting. Caterpillars are easier to control when they are small and therefore insecticide applications are more effective when the majority of caterpillars are in the early stages of development. It is advisable to select pesticides from a different chemical group with each application to try to avoid resistance build up.
	DIPEL WP	0.55 to 1.1 kg/ha (loopers) 110 g to 550 g/ha (others)	0 0	Not effective against Diamondback Moth.
	THURICIDE HPC	2.0 to 4.5 L/ha	0	Use higher rates for loopers. Not effective against Diamondback Moth.
	POUNCE 384 EC	90 to 175 mL/ha	-	Apply when insects or insect damage first appears. 3 days to harvest for cabbage, cauliflower and brussels sprouts. 7 days to harvest on broccoli.

				See note under Decis.
	DECIS 2.5 EC	300 to 400 ml in 350 to 500 L/ha	3 1	Use on cabbage and broccoli only. Pounce and Decis are more effective than other insecticides under cool, fall conditions. Will also control late climbing cutworm. Brussels sprouts.
	GUTHION 240 EC	2.25 to 3.5 L/ha	-	Repeat as necessary. 7 days to harvest on brussels sprouts. 15 days to harvest on broccoli and cauliflower. 21 days to harvest on cabbage.
	SNIPER 240 EC	2.25 to 3.5 L/ha	-	
	GUTHION 50 WP	1.1 to 1.75 kg/ha	-	
	SNIPER 50	1.1 to 1.75 kg/ha	-	
	APM 50 WP	1.1 to 1.75 kg/ha	-	
	LANNATE L 215 SN	1.25 to 2.25 L/ha	-	Apply with low pressure ground equipment. Repeat at 5 to 7 day intervals. 1 day to harvest on cabbage. 7 days to harvest on broccoli, brussels sprouts and cauliflower.
Cabbage looper Imported cabbageworm Diamondback moth larvae *cont'd.*	MONITOR 480 SN	1.1 to 2.25 L/ha	-	Rates above 1.8 L/ha are for severe infestations only. 7 days to harvest on cabbage and cauliflower. 14 days to harvest on broccoli and brussels sprouts.
	THIODAN 4 EC	1.4 to 2.1 L/ha	7	Use lower rates for small larvae.
	ENDOSULFAN 50 WP	1.1 to 1.75 kg/ha	7	
	THIODAN 50 WP	1.1 to 1.75 kg/ha	7	
	CYMBUSH 250 EC	140 ml/ha	3	
	RIPCORD 400 EC	87.5 to 125 ml/ha	3	
	MATADOR 50 EC	100 ml/ha (Imported Cabbageworm, Diamondback Moth) 200ml/ha (Cabbage Looper)	1 (cabbage) 3 (broccoli, cauliflower, Brussels sprouts)	Do not apply more than 3 times per season. Allow 7 days between applications.
	MATADOR 120 EC	42 ml/ha (Imported Cabbageworm, Diamondback moth) 83 ml/ha (Cabbage Looper)	1 (cabbage) 3 (broccoli, cauliflower, Brussels sprouts)	Do not apply more than 3 times per season. Allow 7 days between applications.
WARRIOR	42 ml/ha (Imported	1 (cabbage)	Do not	

	Cabbageworm, Diamondback moth) 83 ml/ha (Cabbage Looper)	3 (broccoli, cauliflower, Brussels sprouts)	apply more than 3 times per season. Allow 7 days between applications.	
ORTHENE 75%	0.75 to 1.1 kg/ha	28	Orthene is a systemic insecticide.	
Flea beetles	VITAVAX RS	22.5 ml or 31 gm of product per kg of seed	-	For direct seeded cabbage, cauliflower, broccoli and brussels sprouts.
	THIODAN 4 EC	1.5 to 2.0 L/ha	7	
	THIODAN 50 WP	1.5 kg/ha	7	
	ENDOSULFAN 50 WP	1.1 to 1.75 kg/ha	7	
	SEVIN XLR Plus	1.25 to 2.25 L/ha	3, 5	Days to harvest is 3 for cabbage and cauliflower, and 5 for broccoli and brussels sprouts.
	MATADOR 120 EC	42 ml/ha	1, 3	1 day to harvest on cabbage. 3 days for broccoli, cauliflower & Brussels sprouts.
	MATADOR 50 EC	100 ml/ha	1, 3	1 day to harvest on cabbage. 3 days for broccoli, cauliflower & Brussels sprouts.
	WARRIOR	42 ml/ha	1, 3	1 day to harvest on cabbage. 3 days for broccoli, cauliflower & Brussels sprouts.
	RIPCORD 400 EC	90 to 125 ml/ha	3	Use up to 3 applications per year.
	DECIS 2.5 EC	300 to 400 ml/ha	3	Use on cabbage only.
	DECIS 5.0 EC	150 to 200 ml/ha	3	
Aphids	CYGON 480 EC	0.75 to 1 L/ha	-	4 days to harvest on cabbage, cauliflower and broccoli. 21 days to harvest on brussels sprouts.
	DIMETHOATE 480 EC	0.75 to 1 L/ha	-	
	LAGON 480 EC	0.75 to 1 L/ha	-	
	THIODAN 4 EC	1.4 to 2.1 L/ha	7	-
	THIODAN 50 WP	1.7 kg/ha	7	
	ENDOSULFAN 50 WP	1.7 kg/ha	7	
	MONITOR 480 SN	1.1 to 2.25 L/ha	-	7 days to harvest on cabbage. 14 days to harvest on cauliflower, broccoli and brussels sprouts.
Cutworms			-	For damage to transplants, see the section on Chemical Control of "Wireworms and Cutworms". For

				mature cabbage, damage can occur when larvae feed on the bottom half of the heads. Insecticide sprays for cabbageworms that reach the area will control cutworms as well.
Thrips	RIPCORD 400 EC	87 to 125 mL/ha	3	Control of thrips may be achieved when spraying for cabbageworms by alternating synthetic pyrethroids with diazinon, Guthion, azinphos-methyl or APM. It is critical to control them at early head formation (3 inch leaf ball).
	CYMBUSH 250 EC	200 ml/ha	3	Add AGRAL 90 surfactant at 300 ml/1000 L of mix.
Slugs (Grey Garden)	LANNATE L 215 SN	3.25 L/ha	30	Apply in 1 application with ground equipment and use sufficient water volume for good coverage. Apply late in the evening when slugs are more active. For brussels sprouts only.

Diseases

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PEST	PESTICIDE (Formulation)	RATE Product	DAYS TO HARVEST	REMARKS
Black rot	Hot Water	-	-	Contact extension service for methods.
Damping Off, Wirestem	VAPAM	Follow manufacturer's directions	-	Fumigate seed beds in fall prior to planting.
	VORLEX		-	
Damping Off	CAPTAN 50 WP	125 to 225 g/100 m^2	-	Apply as a dust to soil or in 50 to 85 L of water per 100 m^2. Work into the upper 8 to 10 cm of soil before planting.
	CAPTAN 80 WP	1.5 kg/1000 L	-	Apply 50 to 85 L per 100 m^2. Work into upper 7.5 to 10 cm of soil.
	MAESTRO 75 DF	1.5 kg/1000 L	-	
Clubroot	QUINTOZENE 75 WP	250 to 270 g/100 L	-	Apply 200 to 350 ml per plant at transplanting. Provide good agitation. When growing transplants in the field, fumigate with Vapam or Vorlex (follow manufacturer's directions). Avoid infested fields. If this is not possible, adjust pH of field soil to 7.2 or use at least 1700 kg/ha hydrated lime in the spring at least 6 weeks prior to planting. Maintain high soil levels of calcium and magnesium.
Downy mildew Black leaf spot *(Alternaria)*	BRAVO 500 F	2.5 to 4.8 L/ha	7	Downy mildew may appear in the seed bed or later in the season. Black leaf spot may appear at any time during season. Cabbage intended for long term storage should be treated 3 to 4 times in the later part of the season. Use a spreader sticker with WP formulations. Brussels sprouts should be sprayed at the first sign of disease after sprouts begin to form. Rovral may be used on cabbage and cauliflower. For *Alternaria* control on storage cabbage apply 1 application of
	ZINEB 80 WP	1.1 to 3.3 kg/ha	7	

	FIXED COPPER	Follow Manufacturer's directions	1	Rovral 7 to 14 days prior to harvest. For *Alternaria* control on cauliflower apply 1 application of Rovral 1 to 2 days prior to tying. Broccoli head rot may be caused by the fungus *Alternaria* or *Pseudomonas* (bacteria). However, bacterial head rot caused by *Pseudomonas* is the most prevalent. Avoid high nitrogen applications, irrigation and pesticide applications during heading. Most pesticides contain surfactants which enhance decay. Cultivars differ in their susceptibility. Contact extension services for details. Fixed copper is registered for use on cabbage, broccoli and cauliflower. However, it may be phytotoxic, especially to cauliflower.
	ROVRAL 50 WP	3.0 kg/ha	7 (cabbage) 5 (cauliflower)	